

# An Overview of the National Nanotechnology Initiative

**E. Clayton Teague**

Director

National Nanotechnology Coordination Office

National Science and Technology Council

*NTP Board of Counselors Meeting \* June 24, 2005*

*Nanotechnology Working Group*

# Nanotechnology Development

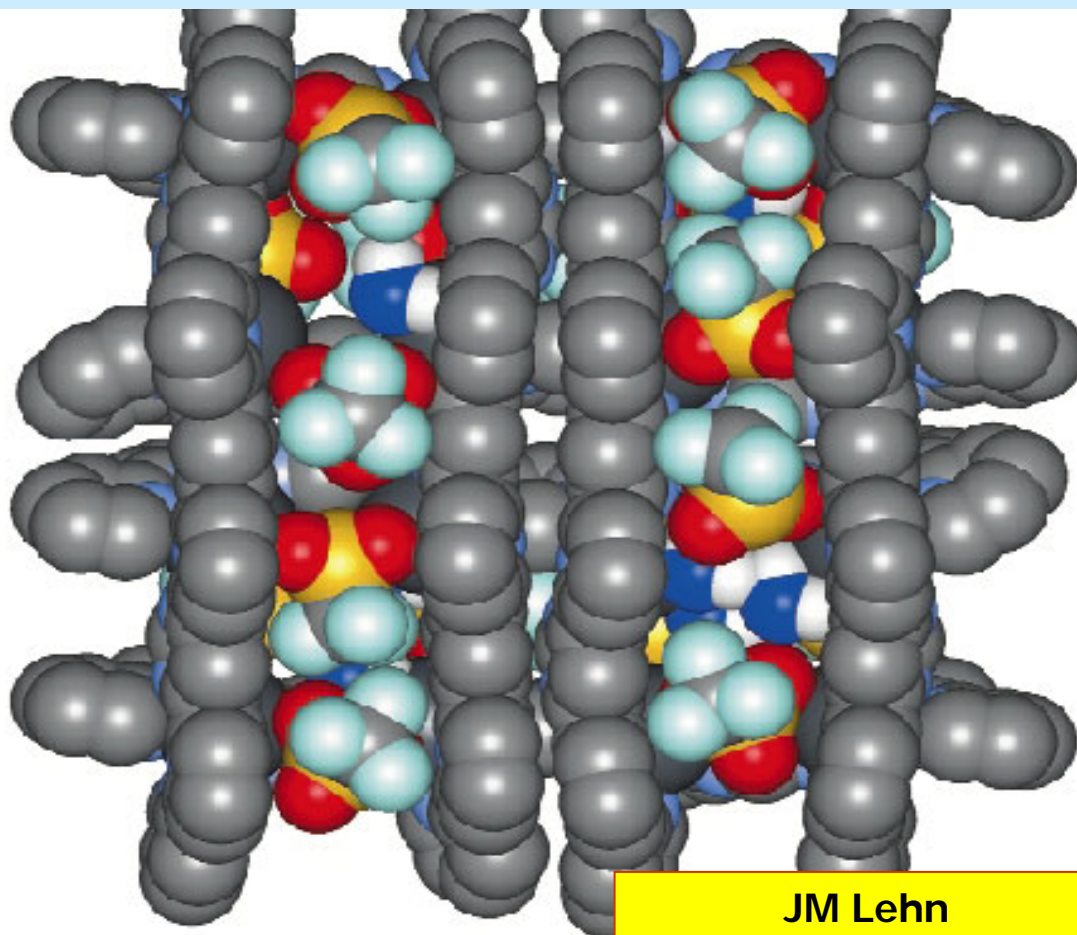
CdSe Quantum Dots

3 nm

4 nm

1968 - H<sub>2</sub>O

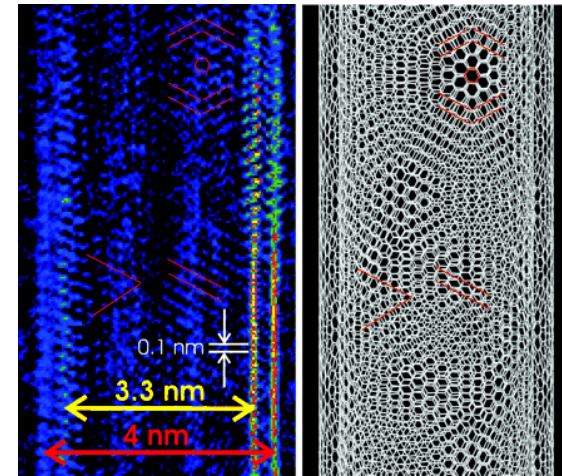
Self-Assembled Lead Supramolecular Array



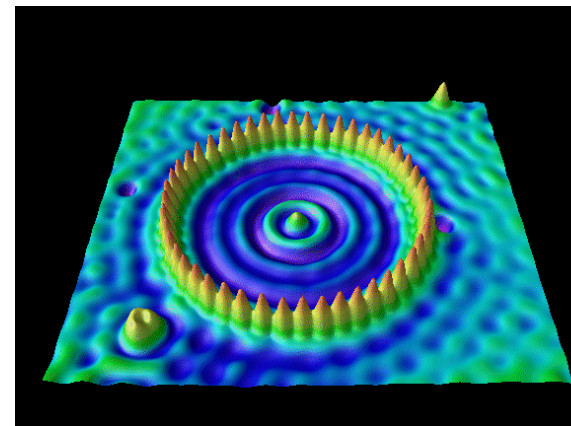
JM Lehn

# What Is Nanotechnology?

- ❖ Research and technology development aimed to understand and control matter at dimensions of approximately 1 - 100 nanometer – the nanoscale
- ❖ Ability to understand, create, and use structures, devices and systems that have fundamentally new properties and functions because of their nanoscale structure
- ❖ Ability to image, measure, model, and manipulate matter on the nanoscale to exploit those properties and functions
- ❖ Ability to integrate those properties and functions into systems spanning from nano- to macro-scopic scales



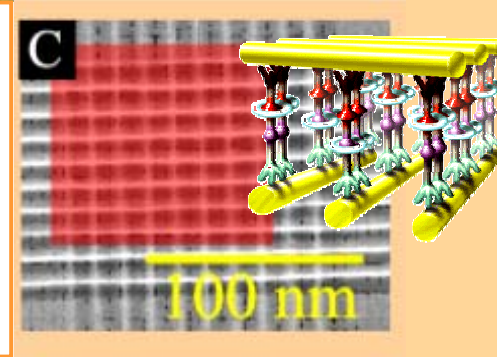
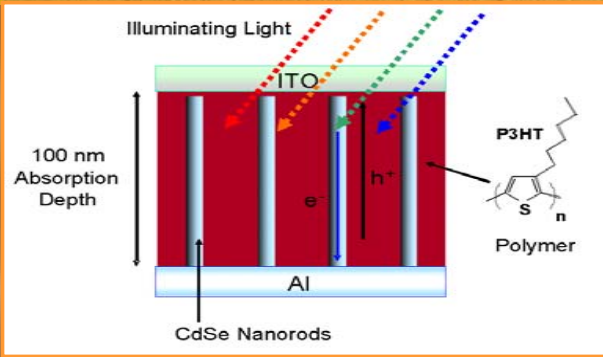
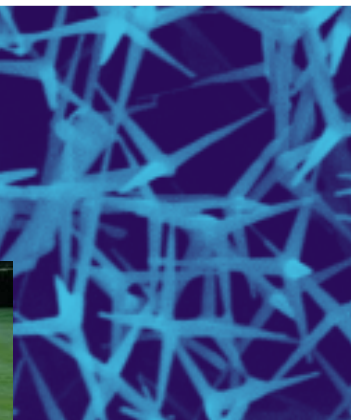
Nanoarea Electron Diffraction  
of DW Carbon Nanotube –  
Zuo, et.al

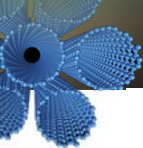


Corral of Fe Atoms – D. Eigler



# NNI Participating Agencies See Widespread Application for Nanotechnology





# Interagency R&D Priorities for FY 2006

*“...In order to ensure that nanotechnology research leads to the responsible development of beneficial applications, agencies also should support research on the various societal implications of the nascent technology. In particular, agencies should place a high priority on research on human health and environmental issues related to nanotechnology.”*

**NSTC**  
**Director, OSTP**

**Committee on  
Environment &  
Natural Resources**

WH: Kathie Olsen  
DOC: Conrad Lautenbacher  
EPA: TBD

Global Change Research

Air Quality Research

Disaster Reduction

Ecosystems

Toxics & Risks

Water Availability & Quality

IWG Earth Observations

IWG on Dioxin

Oceans S & T

**Committee on  
Science**

WH: Kathie Olsen  
NSF: Arden Bement  
NIH: Elias Zerhouni

Research Business Models

Education & Workforce Dev.

Aquaculture

Human Subjects Research

IWG Physics of the Universe

IWG Plant Genome

IWG Dom. Animal Genomics

IWG Prion Science

IWG Trans-boarder Samples

IWG Multinational Orgs\*

R&D Investment Criteria\*\*

Biotechnology

Health and the Environment

**Committee on  
Technology**

WH: Richard Russell  
DOC: Phillip Bond

Networking & Information  
Technology

Nanoscale Science,  
Engineering &  
Technology

Advanced Technologies  
For Education & Training

Manufacturing  
Research &  
Development

Infrastructure

Aeronautics S& T

Social, Behavioral & Econ.

Export Controls for S&T

**Committee on  
Homeland and  
National Security**

WH: Shana Dale  
DOD: Michael Wynne  
DHS: Charles McQueary

National Security R&D

International\*

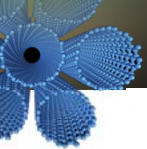
WMD Medical  
Countermeasures

Standards

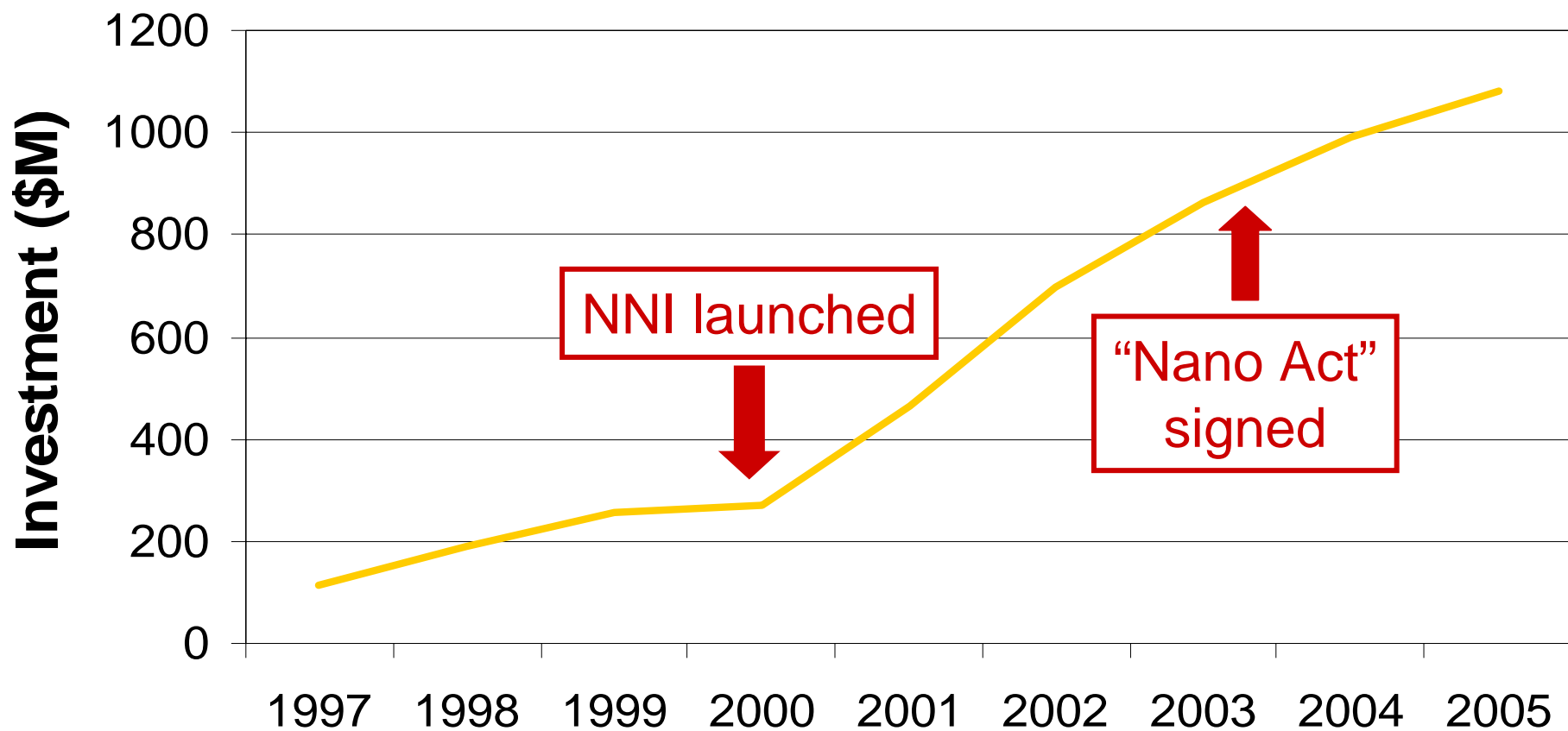
Foreign Animal Disease  
Threats\*

\*in development

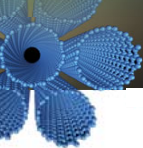
\*\*Informal



# U.S. Nanotech R&D spending







# 21st Century Nanotechnology Research & Development Act of 2003

- Signed by the President on Dec. 3, 2003
- Put into law ongoing activities
- Authorized \$3.7 billion in FY2005-FY2008 among 5 agencies
- “Established” a National Nanotechnology Coordination Office
- Calls for periodic planning and reporting by the NSET Subcommittee
- Calls for the President to establish or designate a National Nanotechnology Advisory Panel
- Calls for a triennial review by the National Research Council

One Hundred Eighth Congress  
of the  
United States of America

AT THE FIRST SESSION

*Began and held at the City of Washington on Tuesday,  
the seventh day of January, two thousand and three*

## An Act

To authorize appropriations for nanoscience, nanoengineering, and nanotechnology research, and for other purposes.

*Be it enacted by the Senate and House of Representatives of  
the United States of America in Congress assembled,*

### SECTION 1. SHORT TITLE.

*This Act may be cited as the “21st Century Nanotechnology*

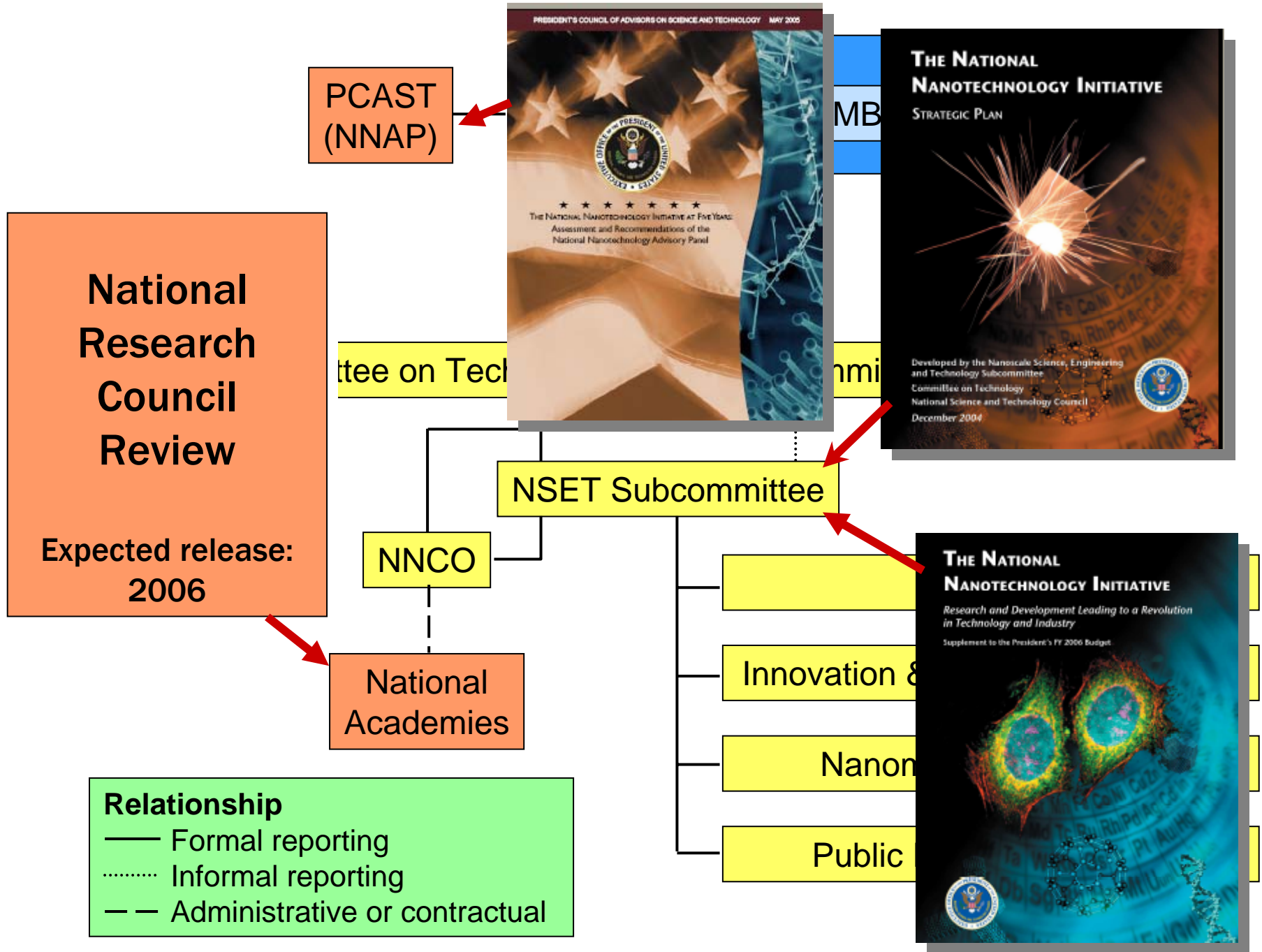


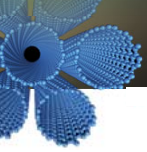
...ties and other partners, which may include States and industry;

(C) make use of existing expertise in nanotechnology in their regions and nationally;

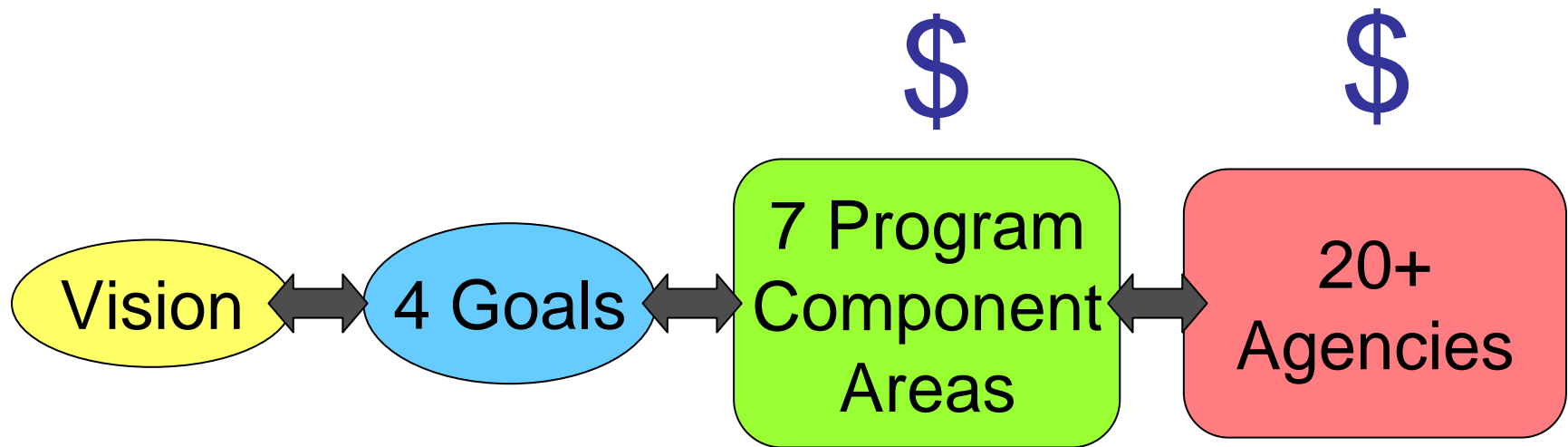
(D) make use of ongoing research and development at the micrometer scale to support their work in nanotechnology; and

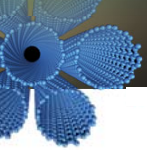






# NNI Strategic Plan (Dec 2004)



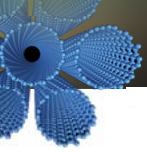


# NNI Vision

*A future in which the ability to understand and control matter on the nanoscale leads to a revolution in technology and industry*

Expedite discovery, development, and deployment of nanotechnology for:

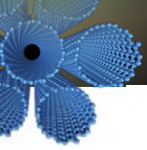
- ❖ Economic benefit
- ❖ National & homeland security
- ❖ Improved quality of life



# NNI Goals

- *Sustain world class R&D*
- *Facilitate technology transfer*
- *Develop infrastructure: education; workforce preparation; facilities & instrumentation*
- *Support responsible development of nanotechnology*





# Areas of investment (aka Program Component Areas)

1. Fundamental Nanoscale Phenomena and Processes
2. Nanomaterials
3. Nanoscale Devices and Systems
4. Instrumentation Research, Metrology, and Standards for Nanotechnology
5. Nanomanufacturing
6. Major Research Facilities and Instrumentation Acquisition
7. Societal Dimensions (EHS, ELSI, Educ.)

# Relationship of PCAs to Goals

## Program Component Areas:

Fundamental Nanoscale Phenomena and Processes

Nanomaterials

Nanoscale Devices and Systems

Instrumentation Research, Metrology, and Standards for Nanotechnology

Nanomanufacturing

Major Research Facilities and Instrumentation Acquisition

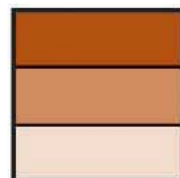
Societal Dimensions

Goal 1: Maintain a world-class research and development program aimed at realizing the full potential of nanotechnology

Goal 2: Facilitate transfer of new technologies into products for economic growth, jobs, and other public benefit

Goal 3: Develop educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology

Goal 4: Support responsible development of nanotechnology



critical to goal

primary relevance

secondary relevance

# Relationship between PCAs and NNI Agency Missions

- Primary
- Secondary
- Agencies w/  
nano R&D \$\$

	Fundamental Nanoscale Phenomena and Processes	Nanomaterials	Nanoscale Devices and Systems	Instrumentation Research, Metrology, and Standards for Nanotechnology	Nanomanufacturing	Major Research Facilities and Instrumentation Acquisition	Societal Dimensions
CPSC	□	□	●	●			●
DHS	●		●	●		□	
DOC (BIS)	□	●	●	●	□		
DOC (NIST)	□	□	□	●	●	□	□
DOC (TA)	□	□	□	□	●	□	●
DOC (USPTO)		●	●	●	●		
DOD	□	●	●	□	●	□	□
DOE	●	●	□	□	□	●	□
DOJ			●				
DOS							●
DOT	●	□	●		●		
DOTreas		●	●				
EPA	□	●	●	□	●		●
HHS (FDA)		□	●				●
HHS (NIH)	●	□	●	□	□		□
HHS (NIOSH)		□			□		●
IC	□	●	●		□		□
ITC		●	●		●		●
NASA	□	●	●		□	□	
NRC			●				
NSF	●	●	□	□	●	●	●
USDA	□	●	●		□		●

## FY 2006 Budget Request (\$ millions) by Agency

	<b>2004 Actual</b>	<b>2005 Estimate</b>	<b>2006 Request</b>	<b>Change 2005 to 2006</b>
NSF	256	338	344	6
DOD	291	257	230	-27
DOE	202	210	207	-3
NIH	106	142	144	2
NIST	77	75	75	0
NASA	47	45	32	-13
USDA	2	3	11	8
EPA	5	5	5	0
NIOSH		3	3	0
DOJ	2	2	2	0
DHS	1	1	1	0
<b>TOTAL</b>	<b>989</b>	<b>1,081</b>	<b>1,054</b>	<b>-27</b>



# FY 2006 Budget Request (\$ millions) by Agency and Program Component Area

	Fundamental Nanoscale Phenomena and Processes	Nano-materials	Nanoscale Devices and Systems	Instrumentation Research, Metrology, and Standards for Nanotechnology	Nano- manufacturing	Major Research Facilities and Instrumentation Acquisition	Societal Dimensions	NNI Total
NSF	95	75	54	12	24	24	60	<b>344</b>
DOD	35	83	99	3	2	6	2	<b>230</b>
DOE	48	33	5	11	0	109	1	<b>207</b>
NIH	46	17	67	6	0	1	8	<b>144</b>
NIST	5	1	2	39	19	8	1	<b>75</b>
NASA	5	17	9	0	1	0	0	<b>32</b>
USDA	1	2	6	0	1	0	1	<b>11</b>
EPA	<0.5	0	<0.5	0	0	0	4	<b>5</b>
NIOSH	0	0	0	0	0	0	3	<b>3</b>
DOJ	0	0	0	0	0	0	2	<b>2</b>
DHS	0	0	1	0	0	0	0	<b>1</b>
<b>TOTAL</b>	<b>234</b>	<b>228</b>	<b>244</b>	<b>71</b>	<b>47</b>	<b>148</b>	<b>82</b>	<b>1,054</b>

# Nanotechnology is 'Now'

## Selected consumer products



**Nanoclay  
Composite**

**Easton CNT is  
Real Nanotechnology**

Mountain Bike Handlebars

1.3 N (0.13 kg) weight

**Carbon Nanotube  
Composite**



resists



**Tennis Racket  
Five Times More  
Rigid**

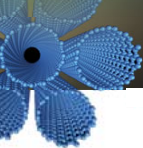
Filtek™ Supreme  
Universal Restorative

Say goodbye to microfills and hybrids with our revolutionary new nanocomposite based restorative.

It's good to be king!

3M ESPE

**Nanosilica Composite**



# Nanotechnology is 'Now'

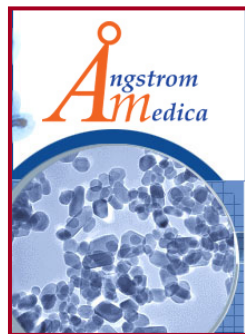
## Selected High Technology products



High  
Temperature,  
Local heat source

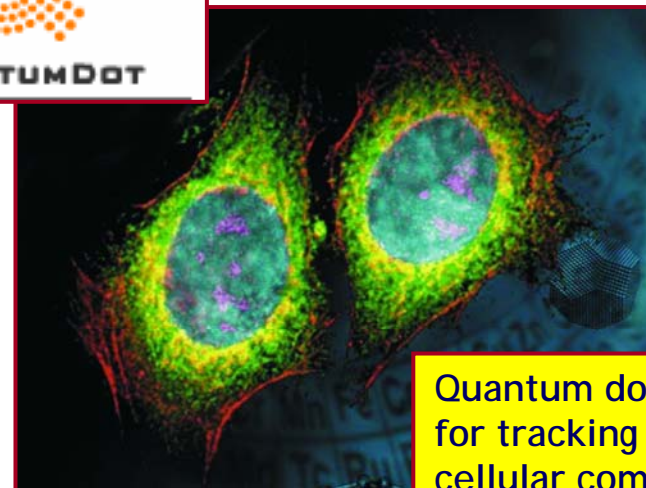


100 mm X 100 mm  
bond area

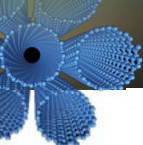


Biocompatible  
nanomaterial bone screws

Bone bonding in 2 weeks and  
osseo-integration in 4 weeks



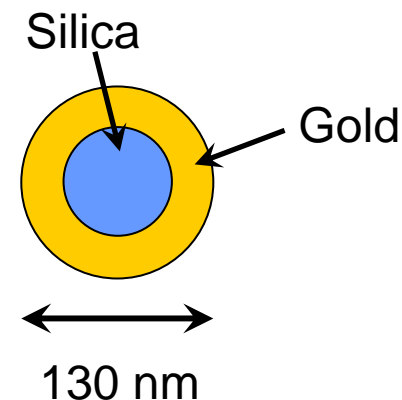
Quantum dot labeling  
for tracking five  
cellular components



# Nanotechnology is “Now”

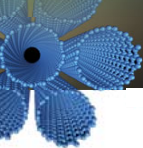
## Product under development: Treating Cancer

- Gold nanoshells (10 nm shell thickness) formed by depositing metal on silica spheres
- Size is *critical*
  - For reaching tumor
  - For absorbing IR energy ( $dT=37^{\circ}\text{C}$ )
  - For optimal transmission through tissue
- *In-vivo* study in mice showed promising results
- *In-vitro* study in human breast carcinoma cells also promising
- Technology developed at Rice Univ. with funding from NSF; start-up company formed to commercialize

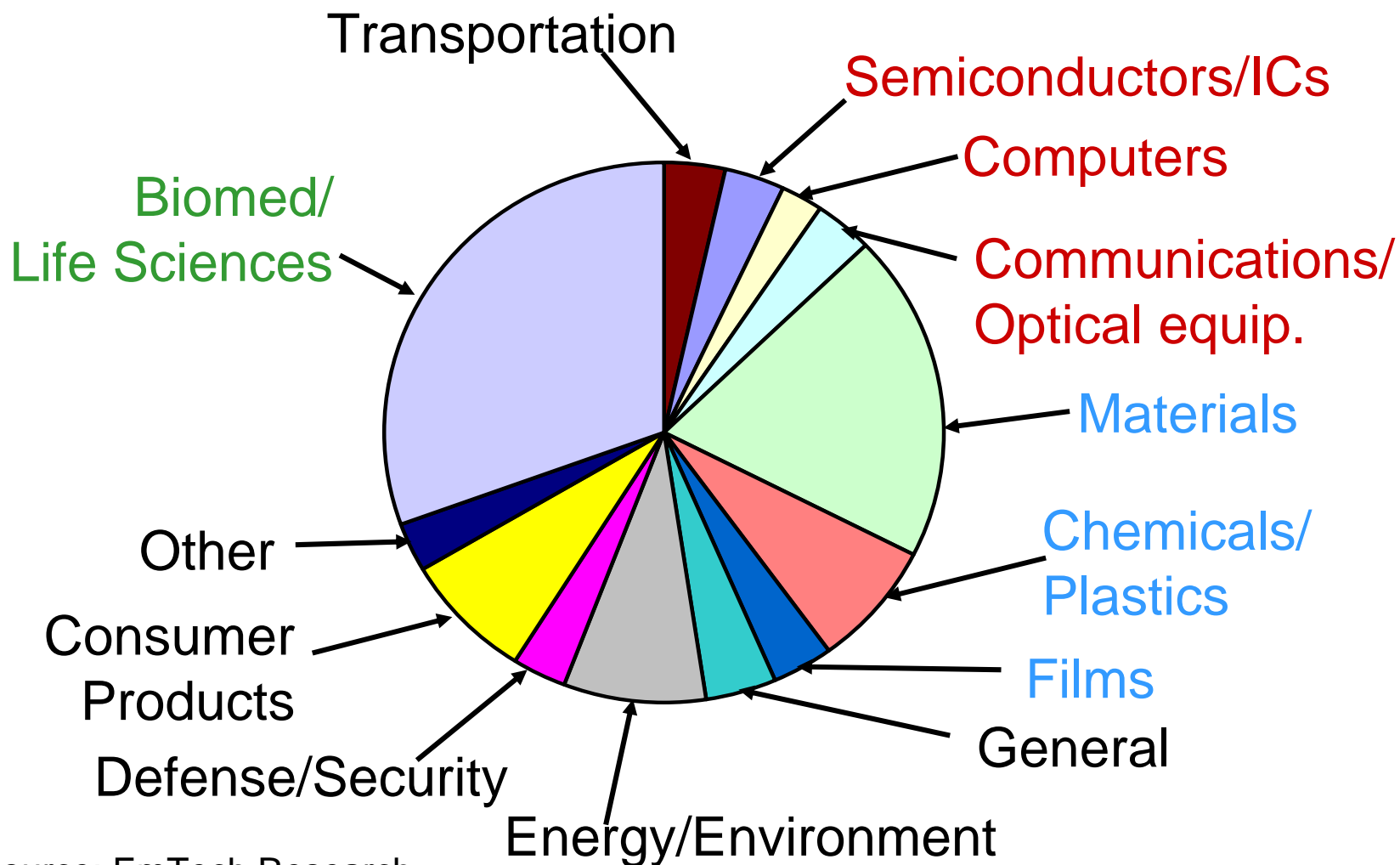


LR Hirsch, RJ Stafford, JA Bankston, SR Sershen, B Rivera, RE Price,  
JD Hazle, NJ Halas, JL West - Rice Univ.      PNAS 23 11/11/2003

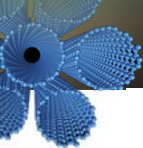




# Target industries for nano suppliers



Source: EmTech Research



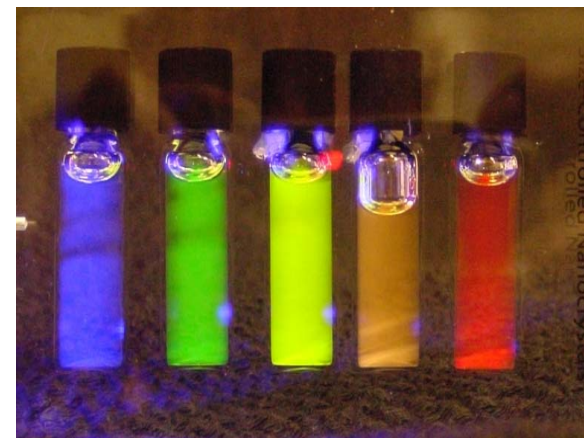
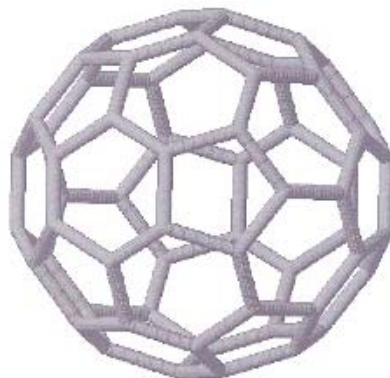
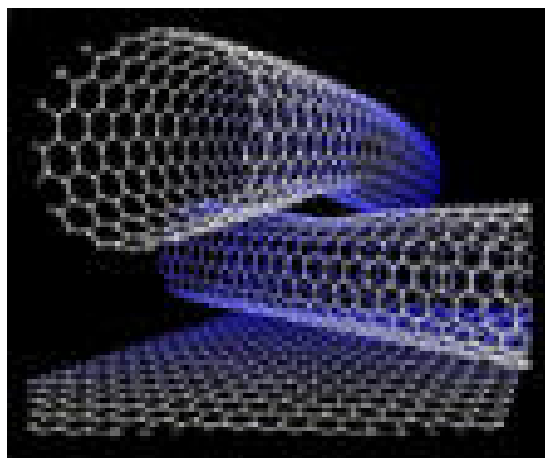
# Existing regulations apply to nano



# NNI research on health effects



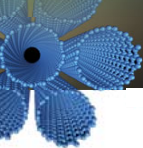
- National Toxicology Program Nanotechnology Safety Initiative initiating toxicology studies of:
  - Nanocrystalline fluorescent semiconductors (aka “quantum dots”)
  - Carbon nanotubes (CNTs) & fullerenes
  - Nanoscale metal oxide particles (e.g.  $\text{TiO}_2$ )



## NNI 2006 Investments (\$ millions) under PCA on Societal Dimensions

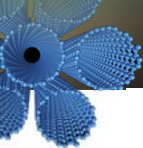
	EHS	Other
NSF	24	35.5
DOD	1	1
DOE	0.5	0.5
NASA	0	0
NIH	3	5
NIOSH	3.1	0
DOC	0.9	0
USDA	0.5	0.5
EPA	4	0
DOJ	1.5	0
DHS	0	0
<b>TOTAL</b>	<b>38.5</b>	<b>42.6</b>





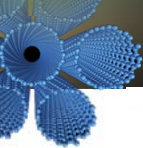
# Examples of NNI support for EHS R&D

- **EPA, NSF & NIOSH:** Solicitation for research on environmental and human health effects of manufactured nanomaterials
- **NIOSH:** Center for Nanotechnology Research
- **NIH/NCI, FDA & NIST:** Nanotechnology Characterization Laboratory
- **DOD/AF:** Multi-disciplinary University Research Initiative to research the relationship between physicochemical characteristics and toxicological properties of nanomaterials



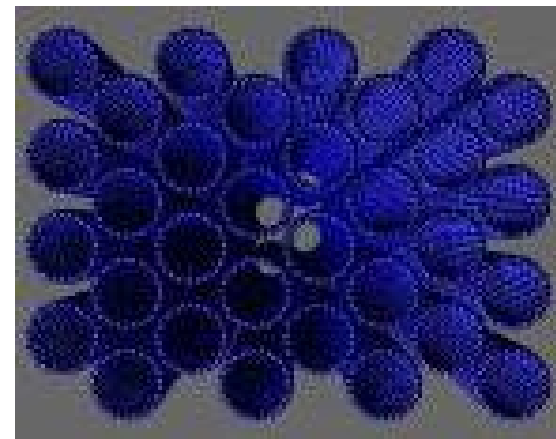
# Nanotechnology Environmental and Health Implications (NEHI) Working Group

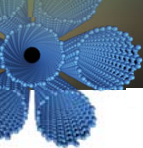
- Subgroup of the NSET Subcommittee
- Co-chaired by FDA and NIOSH
- Members from research and regulatory agencies
- Purposes
  - Provide for exchange of information
  - Facilitate identification, prioritization, and implementation of EHS research on nanotechnology
  - Promote communication of information related to EHS research on nanotechnology



# Nanotechnology standards

- Required for communication; accurate measurement and testing; reliability and quality control.
  - IEEE Nanotechnology Council est. Oct. 2003
  - ANSI Nanotechnology Standards Panel est. Aug 2004
  - ASTM E56 Committee on Nanotechnology Standards est. Jan 2005
  - ISO Technical Committee on Nanotechnology--decision June 2005

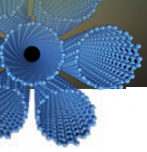




# High Growth Job Training Initiative

- Launched in 2002 to prepare workers to take advantage of high growth, high demand, economically vital sectors.
  - ✓ Biotechnology
  - ✓ Information technology
  - ✓ Automotive
  - ✓ Health care
  - ✓ Advanced manufacturing
  - ✓ Transportation
  - ✓ Energy
  - ✓ Geospatial technology
  - ✓ Construction
- Leverages partnerships among public workforce system, economic development leaders, business and industry, and educators.





# Summary

- NNI has a variety of goals & roles
- Responsible development means advancing benefits while addressing risks
- NNI is funding cutting edge nanoscale scientific research and technology development, including for EHS and...
- Is growing nanotech education, workforce preparation, and public engagement capacity